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THE AMPHIBIANS AND REPTILES FROM RANCHO LA BREA

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INTRODUCTION

Data and records of Pleistocene reptiles and amphibians from the West coast of the United States are rare. A study was therefore made of the herpetological material from Rancho La Brea in the Los Angeles County Museum and the Museum of Paleontology, University of California.

Stock (1949) has recently reviewed the literature on Rancho La Brea and the reader is referred to that paper for any additional information on Rancho La Brea not presented herein.

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PART I. RANCHO LA BREA

LOCATION

Rancho La Brea is in the Wilshire district of the city of Los Angeles, Los Angeles County, California. The pits, when found, occupied a grass-filled open area near the base of the wide bajada descending from the nearby Santa Monica Mountains. The pits are now part of Hancock Park, maintained by the Los Angeles County Museum.

AGE

Geological evidence (Eaton, 1928; Grant and Sheppard, 1939; and Woodring, Bramlette, and Kew, 1946) and paleontological evidence (Stock, 1929, 1949; Merriam, 1906, 1911, 1912, 1914; A. H. Miller, 1929, 1937, 1947; and L. Miller, 1910, 1911, 1912, 1925) suggest that the pits at Rancho La Brea are probably very late Pleistocene; just how late requires further investigation by more modern techniques. Many of the characteristic animals found at Rancho La Brea are similar to or identical with types described elsewhere from Pleistocene horizons. Many representatives of living species are also known from the asphalt. It is not known if there has been continuous deposition in the pits from Late Pleistocene into Recent. It seems possible that the various pits may have been exposed to the surface periodically for varying lengths of time from late Pleistocene to Recent. This view is supported by the reptilian fauna to be discussed below.

The presence of the skull of *Camelops* in a cave in west-central Utah and remains of ground sloths, *Nothrotherium*, in the dry caves of Nevada, Arizona and New Mexico suggest that those species, which have also been found in Rancho La Brea, were living in North America in relatively recent times. Radiocarbon dating (Arnold and Libby, 1951) of the dung of *Nothrotherium* found in the Gypsum Cave, Nevada, gives an age range of from 8,000 to 10,000 years for this material.

The presence of human remains and a few extinct species of birds, with no extinct mammals in pit 10, suggests that this pit is an important link between the Pleistocene and the Recent (Merriam, 1914; Howard and Miller, 1939).

MATERIAL

Herpetological material from Rancho La Brea has been found in Pits A, B, 3, Y, 81, and 101, and in University of California Museum of Paleontology localities 2051 and 2052. Some material in the Los Angeles County Museum is labeled "Rancho La Brea" with no other data. The approximate positions of the majority of these localities may be seen in Fig. 1.

Herpetological material from the early excavations is rare or lacking. In these sites, the larger bird and mammal bones were saved, but the residue, probably containing many amphibian and reptile bones, was discarded. Recently, Dr. W. D. Pierce of the Los Angeles Museum, assisted by Drs. E. E. Hadley and G. A. Kanakoff, made extensive re-examina-

tions of the material from Pits A and B, primarily in search of entomological material. Dr. Pierce has developed a special xylene technique for separating the oil and tar from the smaller organic material. The writer is indebted to him for saving and separating the herpetological material. Dr. Pierce has also washed out the brain cases of some of the Saber-toothed Cats from earlier excavations and has found herpetological remains in them.

The fragility of small amphibian and reptilian fossils, even those from Rancho La Brea, cannot be over-emphasized.

METHODS

All the herpetological material taken from the tar pits has been compared with recent skeletons and checked with descriptions in the literature. In some cases the differences would not be of major osteological character but are those of minor shapes, processes, contours, and proportions. In some cases specific identification was impossible, but in most, the species could be determined.

LIST OF SPECIES

The following is a list of species of Amphibians and Reptiles identified from Rancho La Brea which will be discussed in the following section:

AMPHIBIANS

Bufo nestor	Nestor Toad
Bufo boreas	Western Toad
Hyla sp.	Tree Frog
Rana aurora	Red-legged Frog

LIZARDS

Sceloporus magister	Desert Scaly Lizard
Sceloporus occidentalis	Western Fence Lizard
Uta stansburiana	Side-blotched Lizard
Phrynosoma coronatum	California Horned Lizard
Elgaria multicarinata	Alligator Lizard
Xantusia vigilis	Yucca Night Lizard
Cnemidophorus tigris	Whip-tailed Lizard
Eumeces skiltonianus	Western Blue-tailed Skink

SNAKES

Coluber (*Sensu latu*)	Racer
Pituophis catenifer	Gopher Snake
Lampropeltis getulus	Western King Snake
Crotalus viridis	Western Rattlesnake

TURTLES

Clemmys marmorata	Pacific Pond Turtle

PART II. SPECIES ACCOUNTS

Bufo nestor Camp

Camp (1917) described *Bufo nestor* from Rancho La Brea distinguishing it primarily on the basis of cranial elements. Limb and girdle measurements are not useful in distinguishing *B. nestor* from *B. b. halophilus*. The parasphenoids are, however, useful in distinguishing the two species. No cranial bones, such as those used by Camp in his description, have come to light since his description of *B. nestor*.

Bufo nestor was found in U. C. locality 2051 and is known only from fossil material.

Camp placed *B. nestor* in the *boreas-canorus* group of western toads characterized by not having cranial crests and with the presence of narrow fronto-parietals. Its habits and habitat were probably similar to *B. boreas*. It probably still should be regarded as a distinct species, not intergrading with *B. boreas*, as no intermediates (at least in parasphenoid measurements) can be found. The species is extinct.

Bufo boreas halophilus Baird and Girard

Camp (1917) established the first record of a Pleistocene *Bufo boreas halophilus* from Rancho La Brea. Since then, some 19 "Riker Mounts" of toad bones, all from Pit A, have been available for examination. None of this toad material is different from skeletons of living *B. b. halophilus*. No material of *Scaphiopus* has, as yet, been found in the asphalt. Two fragments of vertebrae of a toad from Pit B are here referred to *B. boreas*.

Camp (1917) gives an account of the comparison of *B. nestor* with Rancho La Brea *B. b. halophilus*, and recent *B. b. boreas* and *B. b. halophilus*, as well as presenting measurements of all of these forms. None of this material will be presented herein other than to add what material has come to light since Camp's work. The following is a summary of the material from Pit A.

A series of 24 parasphenoids, 15 pterygoids, 5 ectopterygoids, and 17 lower jaws (whole) are the only skull material available for examination. The measurements of the parasphenoids fall within the range given by Camp (1917) though they average somewhat smaller than the average given by Camp. Average measurements of specimens from Pit A are as follows: total length, 10.5; total width, 14.5; greatest width of anterior arm, 2.1; and greatest width of wing, 2.2 mm. The ratio of the width of the wing to the total length is 23.8. The lengths and widths of four of the pterygoids are: 9.9-9.5, 9.4-7.0, 9.2-7.1, 8.4-5.5 mm. Lengths and widths of three of the ectopterygoids are: 11.6-7.0, 10.8-6.7, and 12.5-7.5 mm. Lengths of the lower jaw are from 15.1 to 23.3 mm. There are no teeth in the lower jaw.

A total of 41 humeri of amphibians are here all referred to *Bufo*. The humeri of *Rana, Bufo*, or *Scaphiopus* are indistinguishable. Of 30 available amphibian radio-ulna bones, 28 are referred to *B. boreas*, and the other two are identified as belonging to the species following.

By means of size and shape, 49 tibia-fibula have been identified as *B. boreas.* The minimum and maximum of all specimens were 10.3 and 30.0 mm. long. The tibia-fibula of a good-sized recent *Rana aurora draytoni* measures 50.6 mm. in length.

Twenty-seven tarsals and astragali, 1 epicoracoid, 7 clavicles, 17 right and 11 left coracoids, 20 left and 19 right scapulas are all referred to *B. boreas.* The coracoids are much shorter than in *Rana* and the median process is not as wide as is that of *Rana.*

The following measurements have been made of amphibian femurs from Rancho La Brea: Largest fossil, 31.6 mm. long; large middle size, 26.2 mm.; small middle size, 20.2 mm.; small, 10.5 mm. as compared with a recent *Rana a. draytoni* which measured 49.4 mm. long. They thus all agree with *B. b. halophilus* and with the measurements given by Camp (1917).

Many miscellaneous tarsal and carpal bones as well as 20 ilia, 3 coccyx, and 10 ischia are all referred to *B. boreas* on the basis of size and shape, though actually the tarsal and carpal bones cannot be distinguished from *Rana* or *Scaphiopus.* The ischia of this species can be distinguished from *Rana* and *Scaphiopus* by its dorsal extension.

On size and shape 14 sacral, 119 thoracic, and 10 atlas vertebrae are referred to *B. b. halophilus.* It is difficult to distinguish differences between *Rana* and *Bufo* atlases, but the thoracic vertebrae of *Bufo* do not have the high neural spine, or the posterior extension of the neural spine, as in *Rana.*

The two species of *Bufo* here discussed are apparently not related to the Pliocene forms of Kansas (Taylor, 1941, 1942).

The material of *Bufo boreas* from Rancho La Brea was referred by Camp (1917) to *B. b. halophilus* (?). No major differences in the subspecies of *Bufo boreas* are evident, though the Rancho La Brea material may well be of *B. b. halophilus* due to the widespread geographical range of the subspecies today. Pleistocene *B. boreas* may not have yet differentiated into the subspecies known today. Only a large series of skeletons of living and fossil *B. boreas* and its subspecies will give the answer to this problem.

Bufo b. halophilus is found in the area of Los Angeles today and has a wide range extending from northern California through the San Joaquin Valley and south into northwestern Baja California, while the other subspecies, *B. b. boreas,* extends northward to Alaska and eastward to Montana, Wyoming and Colorado.

Hyla sp.

A small radio-ulna and a small tibia-fibula from Pit A are here referred to *Hyla* sp. The tibia-fibula measures 7 mm. in length as compared with 10.3 and 30 mm. as the minimum and maximum for fossil *B. boreas.* The radio-ulna is small (see Fig. 2), the distal end expands widely and the proximal end is weakly bifurcated. Comparative measurements are given below in relation to *Rana aurora.* There are no apparent differences between the bones of *Hyla regilla* and *H. arenicolor.*

It is probable that in the spring, *Hyla* would congregate about the small temporary pools undoubtedly in the Rancho La Brea area and perhaps mistake one of the asphalt pits for a pool. The small fragile bones would probably not preserve well, or they may have been overlooked in collecting.

Rana aurora Baird and Girard

One radio-ulna from Pit A, with the distal ends of the bone not widely separated as in *Bufo* and with the shape of the anterior end thin as compared with *Bufo,* is here referred to *Rana aurora.* It is indistinguishable from present-day skeletons of *R. a. draytoni.* Comparative measurements are as follows:

	Length mm.	Width mm.	
		Anterior	Posterior
Rana aurora—Fossil	14.9	4.5	6.0
Rana a. draytoni—Recent	17.0	6.0	7.1
Bufo boreas—Fossil	16.0	4.3	4.8
Bufo boreas—Fossil	15.6	4.0	5.1
Hyla sp.—Fossil	6.6+	2.5	3.4+

Drawings of the radio-ulnas of these three species are given in Fig. 2, A, B, and C.

One large, isolated vertebra from Pit B is here referred to *Rana aurora* primarily on the basis of the shape of the neural spine.

Today *Rana a. draytoni* occurs in the Santa Monica Mountains approximately two miles north of Rancho La Brea. This subspecies ranges from northwestern California, through the Sierra Nevada and Coast Ranges south into northwestern Baja California.

Sceloporus magister Hallowell

Material from Rancho La Brea localities Pit A and "no data," consisting of 14 dentaries, 7 maxilla, 1 quadrate, 4 frontals, 1 occipital, and 10 parietals are here referred to *S. magister.*

The *Sceloporus magister* quadrate from Rancho La Brea has a dorsolateral thin margin and a deep depression posteriorly whereas *S. orcutti* is shallow posteriorly. The dentary can be distinguished from that of *S. occidentalis* by its larger lize and by the presence of a well developed flat area on the lateral side of the dentary just lateral to the teeth. The occipital may be separated from that of *S. occidentalis* only on the basis of size and minor details of the processes.

Sceloporus magister is not found in the Los Angeles city area today. It is present primarily on the fringes of the desert. The cause of its disappearance from the coastal area is not known. A possible increase in aridity of the area should not have affected a desert-margin species. Possible interspecific competition with *S. occidentalis* might be a cause of its elimination from the area. What effect the increasing human population in the area had on the distribution of the lizard is unknown.

Sceloporus occidentalis Baird and Girard

Material of *S. occidentalis,* taken from Rancho La Brea localities A, 101, Y, 81, and "no data," include 40 dentaries, 24 maxilla, 8 parietals, 15 frontals, 2 occipitals, 3 scapulas, 1 femur and several miscellaneous bones such as parts of pelvic and pectoral girdles, vertebrae, sacra, and hyoids.

The parietals of *S. occidentalis* are quadrangular. The frontals do not expand anteriorly and are usually found to have a median process. The dentaries are larger than in *Uta* and smaller than in *S. magister* or *S. orcutti.* The posterior teeth on the dentary and maxilla are trifid, the anterior teeth are not. There is no flat area just lateral to the teeth on the dentary. The lower end of the dentary extends posteriorly more than the upper does. This species differs from *Sceloporus graciosus* in details, especially as to the parietals and frontals.

The material from Pits A and 81 may be referred to the subspecies *S. o. biseriatus,* living in the area today, to emphasize the close similarity of the fossil and living specimens. The two dentaries and the two maxillae from Pit 101 and the one dentary from Pit Y differ sufficiently so that they are identified as *S. occidentalis* only. The most anterior mental foramen in the dentary from Pit Y is elongate rather than round.

Remains of this species are the most abundant lizard material found in the Rancho La Brea diggings to date and it is also the most abundant lizard in the Los Angeles area today.

Uta stansburiana Baird and Girard

Rancho La Brea material from Pits A, 81, and "no data" consisting of 18 dentaries, 18 maxillae, 17 parietals, 10 frontals, 9 scapulae and numerous girdle and limb elements can be referred to *Uta stansburiana.* Usually the bones of *Uta* can be distinguished by their small size, however, characters do exist that differentiate between this and other genera.

The frontal bone is expanded anteriorly and the posterior portion is extremely thin in the central area. In both fossil and recent specimens the parietal is very thin in the anterior central area and is often broken through. The teeth are usually not trifid. The teeth of *Uta* are small and numerous. The dentary is pointed anteriorly, at least more so than *Sceloporus occidentalis.*

This lizard's remains are very abundant in the Rancho La Brea material and it is also a common species in the area today.

Phrynosoma coronatum (Blainville)

The osteology of the genus *Phrynosoma* has been discussed by Bryant (1911) and recently by Reeve (1952). Fortunately the Rancho La Brea material consists of two posterior temporal spines from Pit A which, by their character, places them with *Phrynosoma coronatum.* According to Reeve (1952) two subspecies, *P. c. frontale* and *P. c. blainvilli,* occur in the Los Angeles area today. A comparison of measurements of these two subspecies and the one Rancho La Brea specimen given below suggests

that the fossil form had not as yet differentiated into the two subspecies. No definite conclusions can be reached, however, based on only one specimen.

Species	Width of base mm.	Distance between tips of spines mm.	Height of spines mm.		Number
			Posterior	Anterior	
Fossil—La Brea	6.0	4.4	6.1	4.4	1
P. c. frontale	6.1	4.5	5.9	3.6	5
P. c. blainvilli	6.8	5.5	6.3	4.2	10
P. p. platyrhinos	4.5	3.7	2.6	2.4	1

Elgaria multicarinata (Blainville)

From Rancho La Brea localities Pit A and "no data," 7 maxillae, 12 dentaries, 5 parietals, 4 frontals, 15 occipitals, 3 pterygoids, 7 angulare and articular bones of the lower jaw, and 1 quadrate are referred to *Elgaria multicarinata.*

Tihen's recent (1949) revision of the genera formerly assigned to *Gerrhonotus* makes identification of this form simple and the reader is referred to his paper for discussion of the osteology. The frontal and parietal are particularly diagnostic and can be easily referred to *E. multicarinata.* The pterygoids have teeth on them and the teeth of the maxillae and dentary are conical. The bones of *E. multicarinata* are larger than any of the *Elgaria coerulens* group, and perhaps on size alone (mean length and width of all Rancho La Brea dentaries 11.6 and 3.1 mm.), may be referred to the subspecies *E. m. webbi.*

Xantusia vigilis Baird

Portions of 2 maxillae and 3 fragments of dentaries from Rancho La Brea Pit 101 are here referred to *Xantusia vigilis.* The general shape of the maxilla of both the fossil and of recent *X. vigilis* is triangular with a wide, flat anterior surface. The maxillae of *X. henshawi* and *X. riversiana* are quadrangular and have no wide, flat anterior surface. The teeth on the maxilla and dentary bones of *Xantusia* are trifid.

Xantusia vigilis does not occur in the area of the tar pits today. It is found in the Mohave and Colorado Desert region just outside the barriers formed by the San Gabriel, San Bernardino, and San Jacinto Mountains. It is not known what could have caused its extinction from the Los Angeles area. It is not known if changes in the human population of the area has caused its elimination from the Los Angeles area. It is possible that the specimens in Pit 101 represent an isolated race or form, diverging from the main *vigilis* stock, with subsequent extinction of this form in the area for unknown reasons. Additional material is needed from Rancho La Brea before the taxonomic status (on the subspecific level) can be determined.

Pit 101 is one that suggests a relatively older age than Pit A. Herpetologically this is emphasized by the *Xantusia* and one specimen of

a *Cnemidophorus* (see below) from this pit. The *Sceloporus* and *Eumeces* from this pit are less like recent specimens.

Cnemidophorus tigris Baird and Girard

Rancho La Brea localities Pit A, 101, and "no data," contain 2 dentaries, 1 maxilla, and 6 frontals that are referred to *Cnemidophorus tigris*.

Maxillary and dentary bones with bifid teeth are easily referred to this genus. The shape and size of the bones, especially the frontal, are also diagnostic (DuBois, 1943). The material is referred to this species on similarity of size and shape. The only other Teiid in the area today is *Cnemidophorus hyperythrus*, from which *C. tigris* can be distinguished by size and general shape of the bones.

The one dentary from Pit 101, when compared with recent *C. tigris*, differs in that the dentary is more robust, larger, and wider. The teeth appear taller. The junction of the fork of the bifurcation of the teeth is more pronounced, especially below the fork. The distance between the two posterior mental foramen is greater than in recent specimens (2.3 mm. compared with an average of 1.6 mm. for recent *C. tigris*). It appears to be an extra large specimen of *C. tigris*. This large size might be explained on the basis of a warmer climate, hence larger individuals, according to Bergmann's rule as modified by Cowles (1945) for cold-blooded vertebrates. It might also be explained on the chance that an unusually large specimen was trapped in the pits. Even though differences are apparent, they do not seem to be significant enough to warrant separating this as a distinct species or subspecies.

Cnemidophorus tigris is found in the Los Angeles area today and is common in the Arroyo Seco, Tujunga, and San Gabriel washes as well as in the Santa Monica Mountains.

Eumeces skiltonianus (Baird and Girard)

Rancho La Brea material from Pits A, 3, Y, 101, and "no data," consists of 11 dentaries, 1 maxilla, and 8 parietals. All are referred to *Eumeces skiltonianus*. The osteology of this genus is presented by Taylor (1935) and is discussed by him in regard to two Pliocene forms (1941). The specimens from the asphalt all agree with the characters of this genus as presented by Taylor (1935, 1941) and with skeletons of recent *E. skiltonianus* and *E. gilberti*. *E. skiltonianus* can be separated from the closely related *E. gilberti* only on the basis of size, *gilberti* being the larger. There are no major osteological differences between the two species, but there are small differences of details of shape of the various bones. The material from Pits 101, Y, and 3 (the latter being washed out of the cranium of a saber-tooth tiger from this pit) seem to be less like recent *E. skiltonianus* than the material from Pit A or "no data."

Eumeces skiltonianus is found living in the area of the tar pits today, whereas *E. gilberti* lives only on the top of the San Gabriel Mountains and in the San Bernardino Mountains.

Coluber sp. (sensu latu)

One partly damaged lower jaw of a snake from Pit 81 is here referred to the genus *Coluber* by reason of the fact that the Meckel foramen is almost closed laterally. The two genera, *Coluber* and *Masticophis* (of Ortenburger, 1928), can be distinguished by the shapes of the nasals, frontals, parietals, and postfrontals; however none of these bones were found in the asphalt. Generic (*sensu strictu*) and specific determination of this snake must await additional material.

Pituophis catenifer (Blainville)

All of the colubrid vertebrae found in the tar pits, with one exception mentioned below, can be referred to *Pituophis catenifer*. The gopher snake material was found in Pit A (96 vertebrae, 3 premaxillae), Pit B (26 vertebrae), U.C. 2051 (1 vertebra), U.C. 2052 (1 vertebra), and Rancho La Brea "no data" (1 vertebra).

These vertebrae are identified as *P. catenifer* on the basis of size and measurements. *Pituophis* lacks the strong subcentrum keel and the heavy top ridge of the neural spine as found in *Lampropeltis*. *Pituophis* has small hook-like processes on the anterior ends of the zygosphene which are generally lacking in *Lampropeltis*. *Lampropeltis* characteristically has rounded anterior corners of the zygosphene. *Pituophis* vertebrae can be distinguished from *Thamnophis* by the absence of the hypapophysis present in that genus. From other genera it differs in size.

Measurements of La Brea, McKittrick, and recent skeletons of *Pituophis catenifer* are presented in another paper (Brattstrom, 1953). Three premaxillae from Pit A are referred to *P. catenifer* on the basis of size and shape. They are not similar to any of the other colubrid premaxillae seen, but they differ from recent *P. catenifer* in small details. The vertebrae appear more like *P. c. annectens* than *P. c. affinis, P. c. deserticola* or *P. c. catenifer*.

Lampropeltis getulus californiae (Blainville)

On the basis of a strongly developed sub-centrum keel and in the presence of rounded anterior corners of the zygosphene, one vertebra bearing no other data than "Rancho La Brea" is identified as *Lampropeltis getulus*. It is distinguished from *Lampropeltis zonata* on size and is referred to this subspecies on the basis of geographic distribution.

Crotalus viridis Rafinesque

Crotalus material is available from Pits A, B, 81, U.C. 2052, and "no data." Previously Gilmore (1938) mentioned that due to lack of material all fossil Crotalids should be referred to *Crotalus* sp. Since 1950 the writer has been engaged in a study of the comparative osteology of the Crotalidae including the species and subspecies of *Crotalus*. All of the species of *Crotalus* can be distinguished by means of osteological characters. It is therefore possible to refer most of the fossil material, including Rancho La Brea specimens, to recent or fossil species on the basis of

size, shape, and comparative measurements. The differences in vertebrae of the various species is sometimes very diagnostic, but some species show great variability. As additional studies of the comparative osteology of the rattlesnakes are in progress, a final analysis will be presented later.

Fifteen vertebrae, 1 pterygoid with 8 teeth, and a questionable presphenoid from Pit 81 can all be identified as *Crotalus viridis*. The material from Rancho La Brea with no data are also of this species. From Pit A there are 7 ribs or fragments of ribs, 3 presphenoids, 1 fragment of a lower jaw and many vertebrae. The presphenoids are variable among snakes and these are only tentatively referred here to *C. viridis*. The ribs are all small, the measurements being similar to present day *C. viridis helleri*. The *Crotalus* vertebrae from Rancho La Brea can be identified as *C. viridis* on the basis of relative proportions of the parts and on the shape and size of the zygosphene, centrum and zygapophyses. A summary of measurements of La Brea, McKittrick and recent skeletons are presented elsewhere (Brattstrom, 1953). The La Brea specimens resemble skeletons of *C. v. oreganus* and *C. v. helleri* more than any of the other subspecies of *C. viridis*. The rattlesnakes from the La Brea pits were larger than average for this species. This is suggested by the material from U.C. 2052 and a few vertebrae from Pits A and B. If Bergmann's rule (as modified by Cowles, 1945) is applicable, the large size of some of these rattlesnakes may indicate a warmer climate.

Crotalus viridis helleri and the very closely allied *C. v. oreganus* occur today from British Columbia to Baja California (the break between the two races being essentially in Santa Barbara County, California). *C. v. helleri* is found today in the Santa Monica Mountains just north of Rancho La Brea.

Clemmys marmorata (Baird and Girard)

Material from Rancho La Brea localities Pit A and "no data" consists of 3 femora, 5 innomonate bones, 2 scapulas, 1 humerus, 1 tibia, 1 fibula, 34 pieces of plastron and carapace, and 41 pieces of marginal dermal scutes. Some turtle material from Pits 3 and 5 is listed in the Los Angeles County Museum catalogue, but has not been found and is apparently lost.

When Hay (1903) described the two western fossil forms, *Clemmys saxea* (Pliocene) and *Clemmys hesperia* (Miocene), from the John Day country of Oregon, he had no skeletons of the recent *C. marmorata* available. The material from Rancho La Brea is easily identifiable with *C. marmorata* and does not differ from it except possibly in size, as seen in Figure 4. *Clemmys saxea*, the Pliocene species, can be separated from *C. marmorata* by the elongate pygal (Fig. 4). *Clemmys hesperia*, the Miocene form, can likewise be distinguished from *C. marmorata* on the shape of the hyoplastron. The hyoplastron of *C. marmorata* is straight laterally whereas in *hesperia* it is curved inward. Whether *C. hesperia* and *saxea* differ is not known as the available material of each fossil does not contain the diagnostic bones of the other species (Hay, 1903, 1908).

Clemmys marmorata is found today in areas of permanent water

from Washington to 31° N. Latitude in Baja California. It occurs today, though rarely, in the Los Angeles area in places of permanent water such as the San Gabriel Mountains, the Arroyo Seco and Los Angeles Rivers (prior to the cementing of the beds of these rivers) and Malibu Creek in the extreme eastern Santa Monica Mountains. It does not occur today in that part of the Santa Monica Mountains just north of Rancho La Brea.

PART III. CLIMATE, ECOLOGY, AND ZOOGEOGRAPHY

FLORA

Plants are usually good indicators of past climates, but unfortunately the material from Rancho La Brea is rather scarce and of the material available only the more obvious species have been determined. The plant material from Pit A has not as yet been studied. It is at present in the process of being separated from the asphalt (Templeton, personal communication). So far the following plants have been identified from Rancho La Brea:

Pinus muricata	Bishop Pine
Pinus sabiniana	Digger Pine
Cupressus sp.	Cypress
Quercus agrifolia	Coast Live Oak
Arctostaphylos sp.	Manzanita
Xanthium calvum	Cockle Burr
Sambucus glauca	Blue Elderberry
Celtis mississippiensis var. *reticulata*	Western Hackberry

The *Cupressus* sp. and the *Pinus muricata* come from relatively older pits in association with the Mastodon and Imperial Mammoth, whereas the other species are from various pits. Beside the two pines mentioned above, another fossil pine, *P. linguiformis* Mason, resembles the Rancho La Brea material (Mason, 1932 and personal communication). The taxonomic status of the *Cupressus* is still in doubt (Mason, 1927) and Mason has suggested (personal communication) that, ". . . all the described species for the state of California might possibly be reduced to just two, a northern species and a southern. Cones alone are not adequate to distinguish these entities, the characters of the bark also being important."

The plants of the older pits would indicate a humid flora, drying slightly to a more arid association of Juniper, *Quercus* and *Arctostaphylos* characteristic of Upper Sonoran Life Zone, with perhaps subsequent drying to today's present level of aridness.

FAUNA

A summary of the ecology of the mammalian faunas is given by Stock (1949) and a summary of the avifauna is presented by Miller and De May (1942). Pierce (1946, 1947, 1948) has been studying the invertebrate fauna of the asphalt. In general, the bird, mammal, and invertebrate faunas suggest a moist climate warming and drying to the condition found today.

AMPHIBIANS AND REPTILES

Table 1 gives a summary of the number of individuals of the various species of reptiles and amphibians from the various pits of Rancho La Brea. The relative number of individuals is also presented in Figure 4. The number of individuals was estimated by counting the highest number of any one bone available for that species (or in the case of paired bones, counting and dividing by two) to give the approximate number of individuals thus far found in the diggings of Rancho La Brea. The number of reptiles and amphibians is small compared to that of the birds and mammals. This is probably due to their small size and to the methods employed in collecting.

It may be seen that most of the material comes from Pit A. This is probably due to the fact that this material was carefully handled and separated from the tar by Dr. Pierce, and hence more of the smaller material was saved. The *Eumeces* from Pit 3 was washed out of the skull of a saber-tooth tiger. Camp has suggested (personal communication) that U.C. locality 2052 is relatively recent. On the basis of herpetological material it is suggested that pits 101, 81, 3, Y, and U.C. 2051 are relatively older than Pits A, B, and 2052. Pit B may be slightly older than A. There is no herpetological material from Pit 9, which contained the *Pinus muricata* and the Imperial Elephant material. Little attention has been paid to the comparative study of the faunas of the various pits, though there are obvious differences. Relative ages for some pits are suggested in some cases (Howard and Miller, 1939), but no analysis by pits has been given in the literature.

Conspicuous by their absence in the asphalt are such forms as the spadefoot toads, *Scaphiopus*, and the garter snakes, *Thamnophis*. Perhaps some of the indistinguishable bones of the amphibian material are of *Scaphiopus*, but its identity in the asphalt must wait until diagnostic material is available. *Thamnophis* should have been found in the asphalt if it had been in the area, as the presence of water would suggest. The vertebrae of this genus are very characteristic with a wide hypapophysis on each centrum. Many of the smaller forms (Salamanders, *Hypsiglena, Tantilla,* etc.) would without doubt have been lost or broken in the movements of the asphalt, or these may have been lost in the diggings that had not been handled with such care as is being done by Pierce. Certain forms not found in the tar pits may be dùe to their absence from the area during the deposition of the pits.

Only one species, *Bufo nestor*, is extinct.

RELATION TO OTHER PLEISTOCENE LOCALITIES IN CALIFORNIA

On the basis of herpetological data, Rancho La Brea contains material that appears to be equal in age, at least in part, to the McKittrick asphalt, but with deposition possibly continuing into Recent times. As judged from conclusions reached on the basis of avian and mammalian faunas (Stock, Merriam, Miller), Rancho La Brea is definitely younger than either Hawver or Potter Creek Caves. Herpetological material tends

to support this view, though there appears to be less of a change in the herpetofauna than has taken place in the mammalian and avian fauna. A summary of the other California Pleistocene herpetological material is presented elsewhere (Brattstrom, 1953).

ZOOGEOGRAPHY

There appears to have been no conspicuous local change in the zoogeography of the reptiles and amphibians of the Late Pleistocene as indicated by the forms found in the asphalt of Rancho La Brea. Most of the forms in the pits can still be found in the immediate vicinity today or in adjacent regions of Los Angeles County such as the Santa Monica, San Gabriel, or Palos Verdes Mountains (Bogert, 1930; Hill, 1948). Only one form, *Bufo nestor*, is extinct. The single species of turtle, *Clemmys marmorata*, is still found in the adjacent areas of Los Angeles County wherever there are permanent streams. Two species, *Xantusia vigilis* and *Sceloporus magister*, occur typically at the edge of the desert today. The factors that caused the disappearance of these species from the area, or whether they were populations separated from the main stock, is unknown. The apparent decrease in rainfall would not affect these two as it would the turtle, nor would it be expected that a small increase or decrease in temperature would affect them both. Strictly Lower Sonoran desert species (*Dipsosaurus*, *Callisaurus*, etc.) have apparently not been in the Los Angeles basin during the time of the tar pits. Other forms might have been kept from entering the asphalt by having different ecological habitats than that which was present at Rancho La Brea (*Lampropeltis zonata*, *Sceloporus graciosus*, *Anniella pulchra*, etc.). Other material, of very small size, is probably present but, as yet, undiscovered.

CLIMATE AND ECOLOGY

It is difficult to suggest paleoclimatic conditions based on the present day ecology of the same or similar forms and their associated faunas and floras, but this is the only means available in most cases.

As a means of estimating the paleoclimate of the time of deposition of the animals in the asphalt, a summary of the optimum body temperatures for existent relatives is given below (Data from Stebbins, 1951; Mullally, m.s.; Cowles and Bogert, 1944; Cole, 1943; Zweifel, personal communication).

Species	Optimum body temperature	Mean or Median
Bufo boreas	16.7-22.2°C	19.5°C
	22-24.5	23.2
Sceloporus magister	34-37	35.5
Sceloporus occidentalis	36.6	36.6
Uta stansburiana	35-38	36.5
Phrynosoma coronatum	34.9	34.9
Elgaria multicarinata	27.4	27.4
Xantusia vigilis	29	29.0
	Total	242.6
	Mean	30.32°C. (86.6°F.)

This is not to infer that the temperatures during the Late Pleistocene were as high as indicated by these data, as these forms can alter their body temperatures by behavior, so that they may maintain their optimum metabolic rates under seemingly unfavorable air temperatures. These animals can, of course, operate for a time at temperatures below their optimum, but not much above the optimum, as these temperatures of reptiles and amphibians are usually just a few degrees below their lethal temperature (Cowles and Bogert, 1944).

Most of the present day reptiles and amphibians represented in the asphalt are characteristic of the Upper Sonoran Life Zone. A few of the species range into coastal Lower Sonoran and/or Dry Transition Life Zones. A few species (*Crotalus viridis, Elgaria multicarinata*) range into higher zones and are probably not good indicators of past climate. Most of the forms are typically open valley, ground-dwellers, (*Bufo boreas, Pituophis, Coluber, Lampropeltis, Uta, Phrynosoma* and *Cnemidophorus*), while some (*Rana aurora, Crotalus viridis, Elgaria,* and *Eumeces*) prefer rocky areas. A few (*Bufo boreas, Xantusia vigilis*) are nocturnal today, *Pituophis, Crotalus viridis,* and *Lampropeltis* are both diurnal and crepuscular, and the remainder are diurnal. A moist situation, with permanent streams or pools, is suggested by the presence of the *Bufo, Hyla, Rana, Eumeces,* and *Clemmys.* The *Rana* (Grinnell and Camp, 1917; Stebbins, 1951) and the *Clemmys* (Storer, 1930; Seeliger, 1945; Carr, 1952) are restricted today in southern California to areas of permanent water.

Notes on the ecology of *Eumeces skiltonianus* according to Rogers and Fitch (1947) suggest that:

"Although it seems to be adaptable to widely different habitats and climates, it appears to favor moderately humid climate. It is apt to be concentrated in localized colonies where there is an abundance of ground cover in the form of dead wood or flat rocks and a good growth of herbaceous vegetation. The localities where *skiltonianus* has been found in the greatest abundance are mostly in or near open woods of blue oak, garry oak, or coast live oak and bay (*Umbellularia*)."

The presence of this lizard in the pits would suggest a more humid climate than in the area today. This is also supported, especially in the case of the older pits, by the presence of the *Cupressus* and *Pinus muricata.*

This evidence would also suggest a pushing northward of the species as a result of increasing aridity of the southern part of its range. This suggestion is supported by the restricted range in the Cape region of Baja California of *Eumeces lagunensis*, which is very similar to *E. skiltonianus*, and which has, by some authors, been considered as a subspecies of *skiltonianus* even though intergradation does not occur (see Rogers and Fitch, 1947, for a discussion).

As based on the ecology of the reptiles and amphibians found in the asphalt and by the inclusion of data derived from the flora and other faunas, the ecological conditions surrounding the asphalt pits was probably greater than at present, as indicated by the plants, aquatic amphibians

and reptiles, and aquatic beetles and bugs. Undoubtedly small permanent streams or pools were present in the area. The temperature was probably the same as today or a little warmer.

There was probably a local diminution of rainfall from a time in which Cypress and Pine were locally found through a time of open, interior and warmer, Juniper-Oak association, which finally gave over to an Oak-woodland Savanna and Coastal Sage-scrub association. The topography was probably, from all geological evidence, the same as today.

CONCLUSIONS

Previous to this study, *Bufo nestor, B. boreas* and *Clemmys* sp. were the only herpetological species that had been identified as coming from the asphalt of Rancho La Brea. As a result of this study, 17 forms, representing approximately 135 individuals, have been identified.

There is no evidence to prove that there has not been continuous or partial deposition in the pits since their formation. The fact that the pits may be of different ages, ranging from Late Pleistocene to Recent, is suggested by the fauna and flora of the various pits.

Bufo nestor is the only extinct amphibian found. Most of the forms studied are identical with living species found in the area today.

Two reptiles, *Xantusia vigilis* and *Sceloporus magister,* are found only on the periphery of the desert today and not in the vicinity of the city of Los Angeles. The reason for the elimination of these two forms from the area is unknown.

An aquatic turtle, *Clemmys marmorata,* is absent in the immediate Los Angeles area today except in areas of permanent water. This would suggest a local diminution of yearly rainfall. This view is supported by the presence of amphibian (*Rana*) and botanical material.

A summary of the ecology of the birds, mammals, amphibians, reptiles, and insects suggests an Upper Sonoran Life Zone. From the discussion of the plants and with a possible differentiation of time of deposition of the various pits, it is suggested that from Late Pleistocene to Recent there was a local transition from a moist climate of *Pinus* and *Cupressus* through a stage of decreasing rainfall and a vegetation of *Quercus agrifolia* and *Juniperus californica,* to the present-day climate and vegetation of Oakwoodland Savanna and Coastal Sage-scrub with subsequent changes in the fauna.

LITERATURE CITED

ARNOLD, J. R.
1951. Radiocarbon Dates. Science 113: 111-120.

BOGERT, C. M.
1930. An annotated list of the amphibians and reptiles of Los Angeles County Calif. Bull. So. Calif. Acad Sci. 29 (1): 1-14.

BRATTSTROM, B. H.
1953. Pleistocene reptiles from California. Copeia 3:

BRYANT, H. C.
1931. The horned lizards of California and Nevada of the genera *Phrynosoma* and *Anota*. Univ. Calif. Publ. Zool. 9 (1): 1-84.

CAMP, C. L.
1917. An extinct toad from Rancho La Brea. Univ. Calif. Publ. Bull. Dept. Geol. 10 (17): 287-292.

CARR, ARCHIE
1952. Handbook of turtles. Cornell Univ. Press, xv-542 pp.

COLE, LA MONT C.
1943. Experiments on toleration of high temperatures in lizards with references to adaptive coloration. Ecology 24 (1): 94-108.

COWLES, R. B.
1945. Surface-mass ratio, paleoclimate and heat sterility. Amer. Nat. 79: 561-567.

COWLES, R. B. and C. M. BOGERT
1944. Preliminary study of the thermal requirements of desert reptiles. Bull. Amer. Mus. Nat. Hist. 83 (5): 261-296.

DU BOIS, E. P.
1943. Osteology of the skull of *Cnemidophorus*. Amer. Midl. Nat. 30 (2): 510-517.

EATON, J. E.
1928. Divisions and duration of the Pleistocene in Southern California. Bull. Amer. Assoc. Petrol. Geol. 12 (2): 111-141.

GILMORE, C. W.
1938. Fossil snakes of North America. Spec. Pap. Geol. Soc. Amer. 9: 1-96.

GRANT, U. S. and W. E. SHEPPARD
1939. Some recent changes of elevation in the Los Angeles basin of southern California and their possible significance. Bull. Seismol. Soc. Amer. 29 (2): 299-326.

GRINNELL, J. and C. L. CAMP
1917. A distributional list of the amphibians and reptiles of California. Univ. Calif. Publ. Zool. 17 (10): 127-208.

Hay, O. P.
1903. Two new species of fossil turtles from Oregon. Univ. Calif. Publ. Bull. Dept. Geol. 3 (10): 237-241.
1908. The fossil turtles of North America. Carnegie Inst. Wash. Publ. 75: iv-547.

Hill, H. R.
1948. Amphibians and reptiles of Los Angeles County. Los Angeles Co. Mus. Sci. Ser. 12: 1-29.

Howard, H. and A. H. Miller
1939. The avifauna associated with human remains at Rancho La Brea, California. Carnegie Inst. Wash. Publ. 514 (3): 39-48.

Mason, H. L.
1927. Fossil records of some West American conifers. *Ibid.* 346: 139-160.
1932. A phylogenetic series of the California closed-cone pines suggested by the fossil record. Madrono 2 (6): 49-55.

Merriam, J. C.
1906. Recent discoveries of Quaternary mammals in southern California. Science, n.s. 24: 248-250.
1911. The fauna of Rancho La Brea, Pt. 1. Occurrence. Mem. Univ. Calif. 1 (2): 197-213.
1912. *Ibid.* Pt. 2. Canidae. *Ibid.* 1 (2): 217-272.
1914. Preliminary report on the discovery of human remains in an asphalt deposit at Rancho La Brea. Science, n.s. 40: 198-203.

Miller, A. H.
1929. The passerine remains from Rancho La Brea in the paleontological collections of the University of California. Univ. Calif. Publ. Bull. Dept. Geol. Sci. 19 (1): 1-22.
1937. Biotic associations and life-zones in relation to the Pleistocene birds of California. Condor, 39: 248-252.
1947. A new genus of Icterid from Rancho La Brea. *Ibid.* 49 (1): 22-24.

Miller, L. H.
1910. Fossil birds from the Quarternary of southern California. *Ibid.* 12: 12-15.
1911. A synopsis of our knowledge concerning the fossil birds of the Pacific coast of North America. *Ibid.* 13: 117-118.
1912. Contributions to avian paleontology from the Pacific coast of North America. Univ. Calif. Publ. Bull. Dept. Geol. 7 (5): 61-115.
1925. The birds of Rancho La Brea. Carnegie Inst. Wash. Publ. 349: 63-106.

Miller, L. H. and I. S. DeMay
1942. The fossil birds of California; an avifauna and bibliography with annotations. Univ. Calif. Publ. Zool. 47 (4): 47-142.

ORTENBURGER, A. T.

1928. The whip snakes and racers, Genera *Masticophis* and *Coluber*. Mem. Univ. Mich. Mus. 1: 1-247.

PIERCE, W. D.

1946. Exploring the minute world of the California asphalt deposits. Bull. So. Calif. Acad. Sci. 45 (3): 113-118.

1947. A progress report on the Rancho La Brea asphaltum studies. *Ibid.* 46 (3): 136-138.

1948. The carabid genus *Elaphrus* in the asphalt deposits. *Ibid.* 47 (2): 53-55.

REEVE, W. L.

1952. Taxonomy and distribution of the horned lizards genus *Phrynosoma*. Univ. Kansas Sci. Bull. 34 (14): 817-960.

RODGERS, T. L. and H. S. FITCH

1947. Variation in the skinks (Reptilia: Lacertilia) of the *skiltonianus group*. Univ. Calif. Publ. Zool. 48 (4): 169-220.

SEELIGER, L. M.

1945. Variation in the Pacific Mud Turtle. Copeia 3: 150-159.

SMITH, H. M.

1946. Handbook of lizards. Comstock Publishing Co. xxi-557 pp.

STEBBINS, R.

1951. The amphibians of western North America. Univ. Calif. Press. 1-506 pp.

STOCK, C.

1929. A census of the Pleistocene mammals of Rancho La Brea, based on the collections of the Los Angeles County Museum. Jour. Mamm. 10 (4): 281-289.

1949. Rancho La Brea, A Record of Pleistocene life in California (4th Ed.). Los Angeles Co. Mus. Sci. Ser. 13: 1-81.

TAYLOR, E. H.

1935. A taxonomic study of the cosmopolitan scincoid lizards of the genus *Eumeces*. Univ. Kansas Sci. Bull. 23: 1-643.

1941. Extinct lizards from Upper Pliocene deposits of Kansas. State Geol. Surv. Kansas Bull. 38 (5): 165-176.

TIHEN, J. A.

1949. The genera of Gerrhonotine lizards. Amer. Midl. Nat. 41 (3): 580-635.

WOODRING, W. P., N. N. BRAMLETTE, and W. S. W. KEW

1946. Geology and paleontology of Palos Verdes Hills, California. U. S. Geol. Surv. Prof. Pap. 207: 1-145.

Table 1

Summary of the approximate number of individuals of reptiles and amphibians from the various pits in Rancho La Brea.

SPECIES	A	B	101	81	3	Y	2051	2052	No data	Total
AMPHIBIANS										
Bufo nestor (extinct)							15			15
Bufo boreas	25	1						15		41
Hyla sp.	1									1
Rana aurora	1	1								2
SNAKES										
Pituophis catenifer	3	1					1	1	1	7
Coluber (*sensu latu*)				1						1
Lampropeltis getulus									1	1
Crotalus viridis	2	2		1				1	1	7
LIZARDS										
Sceloporus magister	6								1	7
Sceloporus occidentalis	14		2	4		1			2	23
Uta stansburiana	11			1					1	13
Phrynosoma coronatum	1									1
Cnemidophorus tigris	6		1						1	8
Elgaria multicarinata	6								1	7
Eumeces skiltonianus	3		1		1	1			1	7
Xantusia vigilis			1							1
TURTLES										
Clemmys marmorata	2								1	3

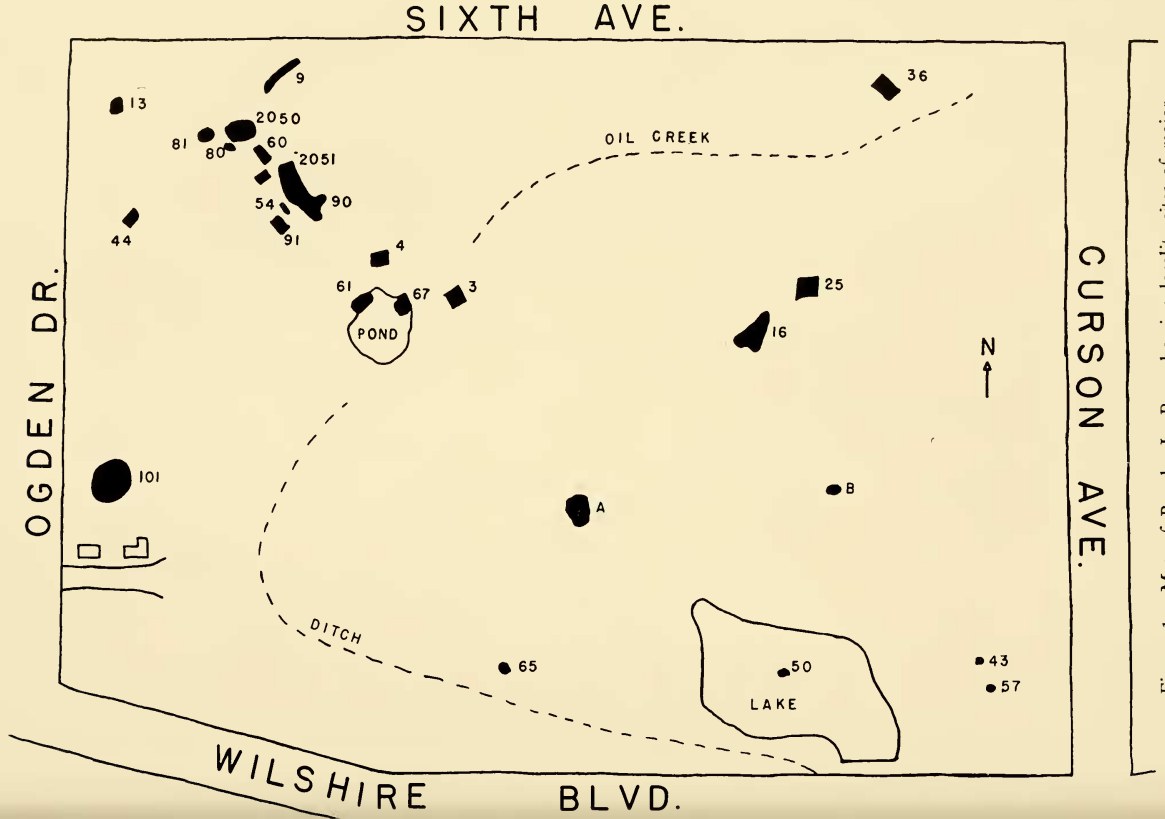

Figure 1. Map of Rancho La Brea showing locality sites of major excavations.

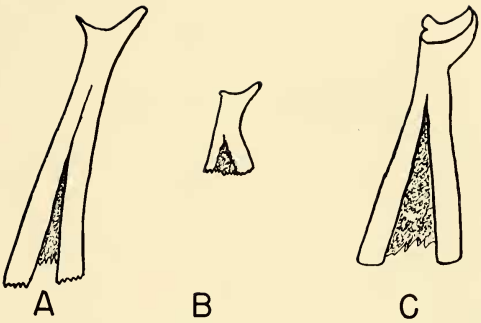

Figure 2. Amphibian radio-ulna bones from Rancho La Brea. A. *Rana aurora,* B. *Hyla* sp., and C. *Bufo boreas.*

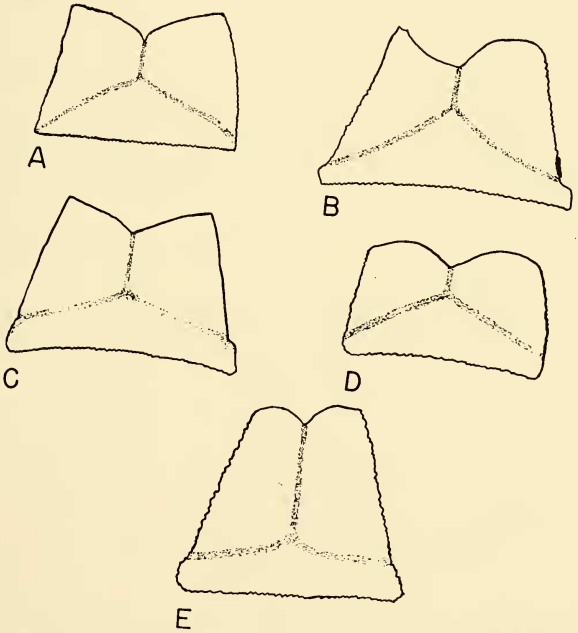

Figure 3. Pygal bones of *Clemmys marmorata* and *Clemmys saxea.* A and B. *C. marmorata* from Rancho La Brea, Pit. A. C. *C. marmorata* from Rancho La Brea with no pit data. D. Recent *C. marmorata* from San Gabriel River, Los Angeles County, California. E. *Clemmys saxea,* Type, Pliocene of Oregon (Redrawn from Hay, 1908, pg. 294).

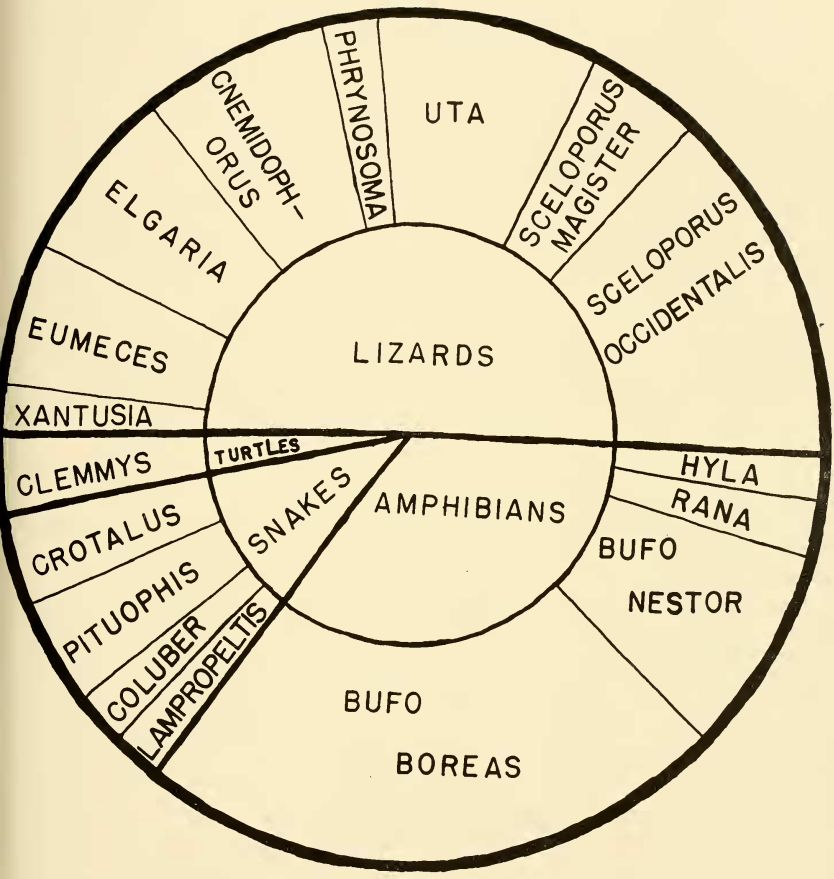

Figure 4. Chart showing the relative abundance of the species of amphibians and reptiles thus far found in Rancho La Brea.